"Ruling out the lost or transient forms which are not perpetuated, we see that the fundamental law here, as elsewhere, is, that all the characteristics are inherited after they are once introduced.

"In former essays, especially written for this purpose, I have tried to show that there was such a general law which is so plain and simple that I have wondered that no authors have made it the basis of investigation except Professor Cope and myself. In every series of animals which I have studied, the same fact appears, namely, that in a given number of generations, inherited characteristics of every kind tend to appear in the descendants at earlier stages than that at which they first occurred in the ancestral forms. Whether characteristics are normal or abnormal, provided they are fixed in the race either by the action of natural selection or by the direct working of physical causes, they are inherited according to this law.

"The law of acceleration appears to me, at present, to show the manner in which characteristics, which are perpetuated, finally either disappear or become fixed in the young, or even in embryo. This conclusion may be followed out by any one who will arrange a series of animals or their shells, according to their adult affinities and their developmental characteristics. He will then see that adult characteristics which are introduced in ancestral forms, tend to reappear at earlier and earlier stages, as he travels along the series."

MAREY'S ANIMAL MECHANISM.[1]—Although the main principles and facts contained in this interesting volume have been already given to the public by way of abstracts in scientific journals, yet it is not too late to call the attention of zoölogists to the value of this work in their studies. Animal mechanics has been much neglected from the difficulties of the subject. The practical bearings are, however, of great importance, for if we knew under what conditions the maximum of speed, force or labor which man either singly or in armies could furnish, might be obtained, a general would know how much of a load a soldier could carry, while if we knew exactly at what pace an animal does the best work, whether he be required for speed or for drawing loads, we could all be Mr. Bergs and prevent much suffering in our noblest of animals, the horse, and that only less useful creature, the ox; while in the good time coming, when electricity may serve as the motive power instead of steam, animal mechanics will reach its apotheosis in a flying machine adapted to the wants of our everyday life, as well as of the traveler, soldier, and all whose calling may impel them to seek a means of locomotion in rapid aerial transit.

[1] *The International Scientific Series. Vol. xi. Animal Mechanism:* a Treatise on terrestrial and aerial Locomotion. By E. J. MAREY, Professor at the College of France, etc., with 117 illustrations. New York, D. Appleton & Co., 1879. 12mo, pp. 283. $1.75.

Our more immediate purpose in noticing this book, has been to call the attention of our zoölogical readers to the chapters on animal motion and electricity in animals, on the harmony between the organ and the function, involving the acceptance of the development hypothesis, and finally the excellent and suggestive chapter on the variability of the skeleton.

After discussing the origin of heat, of mechanical work, and of electricity in the animal kingdom, in order to establish clearly that these forces are the same as those which are seen in the organic world, the author proceeds to study mechanical force, and more especially to follow it through all it applications to work of different kinds which it executes in an animal. Marey adopts the old comparison between an ordinary machine and the animal, the organs of the latter corresponding to the parts of the machine, and then he insists on the strict relations existing between the form of the organs and the character of their functions; he farther maintains that this correspondence is regulated by the ordinary laws of mechanics, "so that when we see the muscular and bony structure of an animal, we may deduce from their form all the characters of the functions which they possess." He notices the fact that in the kangaroo, essentially a leaping animal, there is an enormous development of the muscles of leaping, the *glutei*, the *triceps extensor cruris*, and the gastrocnemial muscles. In birds the function of flight is exercised under very different conditions in different species; so also the pectoral muscles, which move the wings vary greatly in different birds. For example, birds which have a large surface of wing, as the eagle, gull, tern, &c., give strokes of only a slight extent; that depends on the great resistance which a wing of so large a surface meets with in the air. Those birds, however, which have small wings, as the guillemot and the pigeon, move them to a great extent. "If it be admitted that the first mentioned birds must make energetic but restricted movements, and that the second must move with less energy, but with greater amplitude of stroke, the conclusion arrived at must necessarily be that the first ought to have large and short pectoral muscles, while in the second, these muscles should be long and slender." This is proved, says Marey, by a simple inspection of the sternum in different species; "for this bone measures in some degree the length of the pectoral muscles which are lodged in its lateral cavities. Thus birds with long wings have a wide and short sternum; the others have one which is long and slender." "We might multiply," says our author, "indefinitely, examples which prove the perfect harmony between the form of the muscles and the characters of their functions. Everywhere the transverse development of these organs is associated with strength, as in the triceps of the kangaroo, or the masseters of the lion; everywhere also, the length of muscle is connected with the extent of movement, as in the examples which we have just

cited." Now, inquires Marey, is this harmony preëstablished, or rather is it formed under the influence of function in different creatures? Just as we see muscles increase in volume by use, so we may observe them, under the influence of more extended movements, acquire a greater length. "Can we see a displacement of the tendinous attachments of the muscles to the skeleton, under the influence of changes in the force of muscular traction? This problem he proposes to settle by experiment, but before doing so he feels obliged to invoke the development theory, and to show that all through nature, and even in medical science, when an organism, as also an organ, is placed under new circumstances it must change in form, and that "function makes the organ." His philosophy is a substratum of Lamarckianism, *i. e.*, change in the environment ensuring change in the organ and in the organism; with a superstructure of Darwinism, or natural selection, acting after a change or variation has been induced. The application of these views is seen in chapter IX, Variability of the Skeleton, an essay of great interest from the point of view of the laws underlying the sciences of comparative anatomy and palæontology.

Professor Marey shows in this chapter how yielding in its nature is the bony system of the vertebrates during life; that pressure or tension, however slight, will produce the strangest changes of form; the bone, he goes so far to say, is "like soft wax which yields to all external forces," and we may say of the skeleton, that "its form is that which the soft parts with which it is surrounded permit it to assume." He cites cases in surgery and medicine, as well as comparative anatomy, in proof of the proposition "that in the form of the bony structure, everything bears the trace of some external influence, and particularly of the function of the muscles. There is not a single depression or projection in the skeleton, the cause of which cannot be found in an external force, which has acted on the bony matter, either to indent it, or draw it forward."

The great variety of forms in the skeletons of different animals corresponds with the diversity of their muscular systems. Now if the muscles modify the bones, what brings about the various changes in form of the muscles? Marey attempts to demonstrate that the power to which the muscular system is subjected belongs to the nervous system. "The nature of the acts which the will commands the muscles to perform, modifies the muscles themselves, in their volume and their form, so as to render them capable of performing these acts in the best possible manner." The author, from facts in medicine and surgery, shows that it is movement or use which maintains the existence of the muscle; after paralysis or dislocation of bones rendering muscles useless, a muscle may wholly disappear, undergoing either fatty degeneration or fibrous transformation.

With these principles in view, and guided by them, our author then discusses with great originality, and chiefly by the experimental method, locomotion in general, that of man and the horse, and finally the flight of insects and of birds.

PEIRCE'S IDEALITY IN THE PHYSICAL SCIENCES.[1]—It is commonly said by pulpit orators and metaphysicians of the transcendental school, that physical science is lowering and materialistic, that it is concerned with facts alone, and physical, material laws, and that its study tends to deaden the finer sensibilities of the mind and to weaken the grasp of the intellect. How incorrect such a notion is, every thinking scientist realizes; his mind, observant of facts in nature, is continually on the alert, endeavoring to ascertain the meaning of those facts; he is constantly rising from the seen to the unseen; from the actual to the ideal. The late Professor Peirce, whose life was devoted to the study of mathematics, to dry computations carried on year after year, in these posthumous lectures, tells us in impassioned, eloquent words, which every scientist should read, that facts organized into theory "ascend to the very throne of ideality." And if the highest researches of the mathematician are especially transcendental, how much more ideal and transcendental, we would add, become the researches of the biologist, who is concerned with the elusive and subtle laws of life and the mental and spiritual forces of man. No wonder, for example, that the thinking world is profoundly moved by the ideas suggested by evolutionists, and by the study of the origin of things material, for these problems touch upon the deepest, most insoluble problems of man's nature.

The general student of geology and biology will also read this fascinating volume for the sake of the author's views regarding the nebular hypothesis and general cosmogony. Professor Peirce may be regarded as one of the founders of the nebular hypothesis in its modern form. In this book he guides us through the successive steps in nebular history—from chaos to nebula, from nebula to star, and from star to planet.

The author in beginning his exposition of the nebular hypothesis, regards the first chapter of Genesis, rightly interpreted, as "a profound cosmogony. It may not be the revelation of an actual fact, but it teaches where that revelation is to be found; that it is engraved on stone by the all-wise Author; that it is written in the sun, moon and planets; that it is inscribed on the sidereal universe, and that every star is an oracle of God." Coming to the nebular theory, the author treats of nebulosity, of a nebula proper, a cluster, the Milky Way, the Magellanic cloud, of an annular nebula and a spiral nebula; then of the star, and finally the planet, comet and meteor. Geologists will be interested in this philosopher's views as to the cooling of the earth and the

[1] *Ideality in the Physical Sciences.* By BENJAMIN PEIRCE. Boston, Little, Brown & Co., 1881, 12mo, pp. 211.